Title: DAP: Cosmic Plastics D33/6120 vs. Sumitomo Bakelite 52-01

Author(s): Weaver, Leeson Scott
Fisher, Kane J.

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Leeson Weaver, Kane Fisher

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1 Introduction

As soon as you lay eyes on the two data sheets for these materials, Cosmic D33/6120 and Sumitomo Bakelite 52-01, there are some pretty clear differences in mechanical, thermal, electrical, and physical properties. All of the properties that were presented in both of the data sheets are presented in the table below.

Cosmic D33/6120	Sumitomo Bakelite 51-20
Specific Gravity = 1.72	Specific Gravity = 1.93
Water Absorption .25% (after 48 hrs. @ 50°C)	Water Absorption .25% (after 48 hrs. @ 50°C)
Izod Notched Impact Strength 0.5-1.2 ft-lb/in	Izod Notched Impact Strength .59 ft-lb/in
Flexural Strength 13000-15000 psi	Flexural Strength 16000 psi
Compressive Strength 24000-26000 psi	Compressive Strength 18900 psi
Tensile Strength 6000-10000 psi	Tensile Strength 10000 psi
Arc Resistance 145 sec	Arc Resistance 150 sec
Dielectric Strength 340 V/mil (wet)	Dielectric Strength 351 V/mil (wet)
Dielectric Constant 4.2 (1 MHz, wet)	Dielectric Constant 3.5 (1MHz, wet)
Dissipation Factor .015 (1 MHz, wet)	Dissipation Factor .016 (1MHz, wet)
Coeff. of Linear Thermal Expansion 12 10^{-6}/°C	Coeff. Of Linear Thermal Expansion 21 10^{-6}/°C
Key: Mechanical Properties, Physical Properties, Electrical Properties, Thermal Properties	

While this information comes from the data sheets, and not the material used in the headers, it still prom, vides a helpful insight into what qualities are different between the Cosmic and Sumitomo Bakelite DAP. There are three distinct hypotheses relating to *why* the plastics are so distinctly different from one another.

1. Unique composition
2. Different molding procedure
3. Separate molding parameters

A closer look into each of these hypotheses is necessary in explaining why the Sumitomo Bakelite and Cosmic DAPs are so different from one another.

2 Unique Composition

DAP, or diallyl phthalate, is not the only player in making the plastic as reliable as it is. Other additives, like reinforcements, fillers, pigments, and chemical catalysts, are all players in giving DAP its qualities. A rough composition of Cosmic D33/6120 can be found on the corresponding Safety Data Sheet (SDS), found on the website.

The data on Cosmic's SDS reveals that D33/6120 is (by weight):

30-40% Diallyl Phthalate
25-45% Fiberglass
20-30% Mineral Fillers
>5% Pigment(s)
>5% Catalysts

Unfortunately, Sumitomo Bakelite was unable to provide similar information about 52-01 due to it being proprietary.

Even though the formulation of 52-01 could not be obtained, some of the differing properties between D33/6120 and 52-01 still indicate that unique chemical compositions play a part in the differences between the materials. Many of the electrical properties, in addition to the specific gravity, should be equivalent or very close to equivalent if the chemistry of the plastics were the same or similar, but,

considering that all of the electrical properties and specific gravity of D33/6120 differ significantly from 52-01, it would be unreasonable to reject this hypothesis.

3 Different molding procedure

Before explaining how Cosmic and Sumitomo's DAPs might be molded with a different procedure, it is important to know that DAP can be molded in three ways-injection, compression, and transfer molding- and how these procedures are performed.
Injection Molding: a process by which plastic granules are inserted into a closed chamber, slowly moved toward the mold by an Archimedean screw and slowly heated as they approach the mold. At the end of the screw, the then-molten plastic is injected into the mold, where it is cooled and then extracted by an ejection pin.
Transfer Molding: similar to injection molding, plastic granules are placed into a heating element where they are melted, then are transferred, typically by syringe, into a mold. Inside the mold, the plastic cools and hardens until it is ready to be removed from the mold.
Compression Molding: a process in which plastic granules are inserted into the static lower part of the mold, compressed by the upper section of the mold, and then heated and cooled inside the mold
While the data sheets for D33/6120 and 52-01 are created from differently molded specimens, specifically transfer molded specimens of D33/6120 on the Cosmic data sheet and compression molded specimens of 52-01 on the Sumitomo Bakelite data sheet, the headers provided by the two companies are both transfer molded and still behave differently. With this knowledge in hand, it is reasonable to reject this hypothesis.

4 Molded under different parameters

Even if D33/6120 and 52-01 are compositionally similar and are produced with the same molding procedure, one last factor can come into play explaining the differences between the two materials: the conditions under which the parts were molded, specifically temperature and pressure. The higher pressure a material experiences, the lower the necessary temperature to induce an endothermic state of matter change will be, and vice versa. However, these seemingly small differences could play a massive factor in the properties of the resulting material, especially if it is a compound, like D33/6120 or 52-01.

With the D33/6120 data sheet and Sumitomo's DAP Processing Guide (acquired by requesting additional information from Sumitomo), it becomes pretty easy to compare the recommended transfer molding conditions:

Cosmic D33/6120 (recommended)	Sumitomo Bakelite 52-01 (recommended)
Molding Pressure 500-8000psi	Molding Pressure 2500-5000psi
Molding Temperature 135-190°C	Molding Temperature 160-180°C
Mold Shrinkage .001-.004 in/in	Mold Shrinkage .002-.004in

Although the extremes of the D33/6120 molding parameters differ somewhat from the 52-01 parameters, D33/6120 tends to be molded in the middle of the parameters, which all more or less match up with the conditions under which 52-01 parts are produced, which makes it not unreasonable to reject this third hypothesis, if we were just looking at the recommended molding parameters.
However, the actual/experimental parameters under which the parts were molded by New Dynamics differ from what was recommended:

5 Conclusion

Having rejected hypothesis 2 but not 1 and 3, it might be reasonable to conclude that the differences between the materials are due to unique formulations and/or molding parameters, but a deeper analysis of the two parts would be helpful in providing more conclusive results.

However, noting the different specific gravities of the materials is important here because that difference indicates different densities for the samples in the Technical Data Sheets; specifically about 1.7200 g/mL for D33/6120, and roughly 1.9300 g/mL for 52-01. Given that the molding parameters between Cosmic's transfer-molded specimens and Sumitomo's compression-molded specimens are quite similar, this remarkable discrepancy is unlikely to be caused by anything other than chemical composition, regardless of the different molding parameters that New Dynamics implemented since the corresponding data comes from Technical Data Sheets, not New Dynamics. Strangely, however, the masses of the D33 and 52-01 parts from New Dynamics are 0.77g and 0.74g, respectively, which completely contradicts the accurate density calculations based on specific gravity.

The higher density of 52-01, assuming that similar amounts of filler, catalyst, and pigment are present in each material, reveals that 52-01 likely has a higher concentration of fiberglass, which has a considerably higher density than diallyl phthalate. This is also a reasonable assumption to make because pigments, catalysts, sometimes referred to as prepolymers, and mineral fillers should have standardized concentrations across most materials since little catalyst should be necessary once the material is formulated/polymerized, pigments are effective at lower concentrations, and mineral fillers serve as additional reinforcement to the fiberglass. A higher concentration of fiberglass also might provide an explanation as to why New Dynamics was encountering difficulties casting 52-01 at the recommended parameters since the material may be more difficult to work with because the higher percentage of fiberglass would result in a higher melting point for the material, and any fiberglass that did not become molten could have caused the voids in the 52-01 parts.